Practice Problems

Moles (Vocabulary: mole, molar mass, representative particles, Avogadro's number)

1) Determine the molar mass of the following compounds:

a) HCl = 36g/mol

b) $Mg_3(PO_4)_2$ 262g/mol

3(24) + 2(31) + 8(16)

c) H_2PO_4 2 + 31 + 64 = 97g/mol

d) $Ca(C_2H_3O_2)_2$ 158g/mol

40 + 4(12) + 6(1) + 4(16) =

2) Determine the number of moles in each of the following:

a) 632g $Ca(C_2H_3O_2)_2$ $\frac{632g}{158g/mol}$ = 4.0 mole $Ca(C_2H_3O_2)_2$

b) 294g H_3PO_4 294g / 98g/mol = 3. mol H_3PO_4

c) 990g HCl 990g / 36 g/mol = 27.5 mol HCl

3) Determine the number of grams in the following:

a) 1.4 mol HBr 1.4 mol x $\frac{81g}{mol}$ = 113.4 g

b) 0.26 mol Fe 0.26 mol Fe x $\frac{56g}{mol}$ 14.6 g Fe

c) 2.74 mol CO_2 2.74g x $\frac{44g}{1mol}$ = 120.6g

4) Determine the number of representative particles in the following:

a) ~~1.4 mole of Mercury~~ x 6.02×10^{23} # moles x 6.02×10^{23} =

b) ~~990 g NaCl~~ $\frac{990}{58} \times 6.02 \times 10^{23}$

c) ~~27.4 L CO_2 (gas)~~ $\frac{27.4}{22.4} \times 6.02 \times 10^{23}$ =

Chemical Quantities (Vocabulary: percent composition, empirical formula, molecular formula)

1) Determine the percent of calcium in calcium phosphate, $Ca_3(PO_4)_2$

3(40) 120
2(31) 62
8(16) 128 310g/mol

$\frac{120g\ Ca}{310g/mol} \times 100\% = 38.7\%Ca$

2) Determine the mass percent of nitrogen in calcium nitrate, $Ca(NO_3)_2$ 17.1%N

Ca = 40g
N = 28g
O = 96g 164g/mol

$\frac{28g}{164g} \times \frac{40g}{164g} \times 100\% =$ ~~24.4%~~ ~~20.4%~~

Raw Fr. $C_{\frac{4.35}{2.16}} H_{\frac{13.0}{2.16}} O_{\frac{2.16}{2.16}}$ → $C_2 H_6 O_1$ → C_2H_6O

3) What is the empirical formula of a compound that contains 52.2% C, 13.00% H, and 34.80% O?

$C = \frac{52.2g}{12} =$ $H = \frac{13.0}{1.0} = 13.0$ $\frac{34.8g}{16g} =$

4) Calculate the empirical formula of a compound containing 13.28 g K, 17.71 g Cr, and 19.01 g O.

$K = \frac{13.28g}{39.1g} =$ $Cr = \frac{17.71g}{52g} =$ $O = \frac{19.01g}{16.0g} =$

5) Calculate the molecular formula of a compound whose molar mass is 60.0 g/mol and empirical formula is CH_4N.

emp formula wt = 12 + 4 + 14g = 30g/mol $2 = \frac{60g/mol}{30g/mol}$

$2(CH_4N) = C_2H_8N_2$

6) Calculate the molecular formula for a compound that is 49.3% C, 6.9% H and 43.8% O with a molar mass of 146 g/mol.

$C = \frac{49.3g}{12g} =$ $O = \frac{43.8g}{16g} =$

$H = \frac{6.9g}{1} = 6.9$

Chemical Reactions (Vocabulary: physical property, chemical property, physical change, chemical change, 5 reaction types)

1) What are the four signs of a chemical change?

① precipatate forms ③ light released

② heat release ④ gas released

2) Balance the following reactions and identify the reaction type:

DR a) ___2___ $Al(NO_3)_3$ + ___3___ H_2SO_4 → ____ $Al_2(SO_4)_3$ + ___6___ HNO_3

Decomp b) ___1___ NH_4NO_3 → ___2___ H_2O + ____ N_2O

Complete Combustion c) ___1___ C_5H_{12} + ___8___ O_2 → ___5___ CO_2 + ___6___ H_2O

10

+6

Comps.

d) 4 Fe + 3 O_2 → 2 Fe_2O_3

SR

e) 1 Mg + 2 $AgNO_3$ → 1 $Mg(NO_3)_2$ + 2 Ag

3) Predict the products and balance the following chemical equations:

a) (synthesis) Ag + O_2 → ~~$2Ag_2O$~~

$4Ag + O_2 \rightarrow 2Ag_2O$

b) (decomposition) Li_2O →

$2Li_2O \xrightarrow{\Delta} 4Li + O_2$

c) (double replacement) $(NH_4)_3PO_4$ + $BaCl_2$ →

$(NH_4)_3PO_4 + BaCl_2 \rightarrow NH_4Cl + Ba_3(PO_4)_3$

d) (double replacement) $NaC_2H_3O_2$ + $Hg(NO_3)_2$ →

$NaC_2H_3O_2 + Hg(NO_3)_2 \rightarrow NaNO_3 + Hg(C_2H_3O_2)_2$

e) (single replacement) Na + $AlCl_3$ →

$3Na + AlCl_3 \rightarrow 3NaCl + Al$

f) (single replacement) Zn + $Pb(NO_3)_2$ →

g) (single replacement(Br_2 + KI → NO Rxn

h) (combustion) C_3H_7OH + O_2 →

Complete

$2C_3H_7OH + 9O_2 \rightarrow 6CO_2 + 8H_2O$

2 + 16

6C 16H

12 8 20

$6\text{ mol NaOH} \times \frac{40\text{ NaOH}}{1\text{ mol NaOH}}$

Stoichiometry (Vocabulary: mole ratio, volume, mass, percent yield)

1) Calculate the mass of NaOH needed to react with 196g of H_3PO_4 in order to produce water and sodium phosphate according to the following **unbalanced** reaction:

3H = 3
1P = 31
4O = 64
98

$\times 3$ $\quad 196\text{g}$ $\quad \times 3$ $\quad 240\text{g}$ $\quad \times$ $\quad Na_3PO_4$ $\quad Na = 23$ $\quad O = 16$

$3\,NaOH + H_3PO_4 \longrightarrow 3\,H_2O + Na_3PO_4$

$196\text{g } H_3PO_4 \times \frac{1\text{ mol } H_3PO_4}{98\text{g } H_3PO_4} \times \frac{3\text{ mol NaOH}}{1\text{ mol } H_3PO_4} \times \frac{40\text{g NaOH}}{1\text{ mol}} = 240\text{g}$

2) Calculate the mass of $CaCO_3$ produced when 254 grams of Na_2CO_3 are reacted according to the following **unbalanced** reaction:

254g $\quad \times \quad \times \quad \times$ 2g

$Na_2CO_3 + Ca(OH)_2 \rightarrow 2\,Na(OH) + CaCO_3$

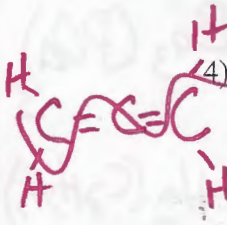
$254\text{g } Na_2CO_3 \times \frac{1\text{ mol } Na_2CO_3}{106\text{g } Na_2CO_3} \times \frac{1\text{ mol } CaCO_3}{1\text{ mol } Na_2CO_3} \times \frac{100\text{g } CaCO_3}{1\text{ mol } CaCO_3} =$

46
12
58
48

3) Calculate the moles of Cu needed to produce 2.25 moles of Ag according to the following **unbalanced** reaction:

$Cu + 2\,Ag(NO_3) \rightarrow 2\,Ag + Cu(NO_3)_2$

$2.25\text{ mol Ag} \times \frac{1\text{ mol Cu}}{2\text{ mol Ag}} = 1.125\text{ mol Cu}$



4) Calculate the volume of oxygen gas needed to produce 6.5 Liters of CO_2 according to the following **unbalanced** reaction:

$\quad$ XL $\quad$ 6.5L

$C_3H_4 + 4\,O_2 \rightarrow 3\,CO_2 + 2\,H_2O$

$6.5\text{L } CO_2 \times \frac{1\text{ mol } CO_2}{22.4\text{L}} \times \frac{4\text{ mol } O_2}{3\text{ mol } CO_2} \times \frac{22.4\text{L } O_2}{1\text{ mol } O_2} =$

5) Calculate the volume of O_2 that is needed to react with 112g Fe to make iron (III) oxide? (Write balanced equation first) $4\,Fe + 3\,O_2 \rightarrow 2\,Fe_2O_3$ @ STP?

$112\text{g Fe} \times \frac{1\text{ mol Fe}}{56\text{g Fe}} \times \frac{3\text{ mol } O_2}{4\text{ mol Fe}} \times \frac{22.4\text{L } O_2}{1\text{ mol } O_2} = 33.6\text{L } O_2$

6) Calcium carbonate, $CaCO_3$, decomposes and produces 2.26g calcium oxide, CaO. If the theoretical yield is 2.68g, what is the percent yield?

$CaCO_3 \rightarrow CaO + CO_2$

$\frac{\text{actual value}}{\text{theoretical value}} \quad \frac{2.26\text{g } CaCO_3}{2.68\text{ } CaCO_3} \times 100\% =$

84.4%

States of Matter (KMT) and Behavior of Gases

1) List the main statements of Kinetic Molecular Theory (KMT).

① every thing is made of tiny particles
② the tiny particles are in constant motion

2) Describe how the following variables affect the behavior of gases. Sketch graphs of each relationship.

a) Pressure and volume

b) Pressure and moles

c) Pressure and temperature

d) Volume and temperature

3) What are STP conditions?

Standard Temp = 273 k or 0°C
Standard Pressure = 1 atm or 760 mm Hg (see ref sheet)

4) What is the conversion between temperature in Celsius and Kelvin?

$K = C^0 + 273$

5) List the conversions for pressure. (You don't have to memorize them, but you should be familiar with them)

See Reference

6) The initial temperature of a gas is 43°C. Calculate the final temperature if the volume changes from 500 mL to 350 mL at constant pressure.

273
43
316

$P_1 = P_2$

$\frac{1(500)}{316} = \frac{350(1)}{T_2}$

$(316)(350) = (500)T_2$

$553.8\ K$

7) Calculate the original volume of a gas at –10°C if the final volume of gas is 200 gallons at 25°C and pressure is held constant.

$\frac{x(1)}{263} = \frac{200(1)}{298} = 176.5\ gal$

8) Calculate the final pressure on a balloon if its volume changes from 250 ft^3 at 770 mm Hg to 1000 ft^3 with constant temperature.

$\frac{(250\ ft^3)(770\ mm\ Hg)}{1} = \frac{(1000\ ft^3)(x)}{mm\ Hg\ 1}$

192.5

$P = 1\ atm$

$T = 273$

$V_1 = V_2$

9) A rigid vessel of gas at standard temperature and pressure (STP) is heated to 900°C. Calculate the new pressure.

1173 K

$273 + 900 = 1173$

P_2

$\frac{(1)(1\ atm)}{273} = \frac{(1)(P_2)}{1173}$

$P_2 = 4.3\ atm$ or $3265.5\ mm\ Hg$

10) A 150 mL air sample has a P of 230 torr at a temperature of 23°C. If the T is raised to 58°C and the volume expands to 360 mL, what will the new pressure be?

$273 + 23 = 296$

$\frac{(150\ mL)(230\ torr)}{296\ K} = \frac{(P_2)(360\ mL)}{331\ K}$

$P_2 = 107.2\ mL$

11) A gas at 1 atm and 0°C has an initial volume of 5 L. The pressure of the gas increases to 2 atm as the temperature is raised to 105°C. What is the new volume?

$\frac{(1\ atm)(5\ L)}{273} = \frac{(2\ atm)(X)}{378}$

$V_2 = 3.46\ L$

12) The volume of a gas-filled balloon is 300 mL at 30°C and 795 mm Hg. What would the volume be at STP?

$\frac{(795\ mm\ Hg)(300\ mL)}{303\ K} = \frac{(760\ mm\ Hg)(X)}{273}$

$V_2 = 282.7\ mL$

13) If I have 4 moles of gas at a pressure of 5.6 atm and a volume of 12000 ml, what is the temperature?

$(5.6)(12000\ mL) = (4.0)(82)(T)$

$T = 7\ moles$

14) If I have an unknown quantity of gas at a pressure of 912 torr, a volume of 31000 ml, and a temperature of 87°C, how many moles of gas do I have?

$273 + 87 = 360$

$(912\ torr)(31\ L) = x\ (.082)(360K)$

$957.7\ mol$

15) If I contain 3 moles of gas in a container with a volume of 60 liters and at a temperature of 400K, what is the pressure inside the container?

$(P)(60) = (3)(0.082)(400K)$

$P = 1.6\ atm$

273
56
29

16) If I have 7.7 moles of gas at a pressure of 68 mm Hg and at a temperature of 56°C, what is the volume of the container that the gas is in?

$V(68\text{ mm Hg}) = (7.7)(62.4)(329)$

2324.7 L

Solutions (Vocabulary: solvent, solute, saturated, unsaturated, supersaturated, electrolyte, nonelectrolyte, spectator ions, colligative property)

1) In which solution is the solubility of a gas higher – cold water or hot water? Why?

gases are more soluble in cold H_2O

2) What three things can you do to get sugar to dissolve faster in water?

1. heat solution
2. stir solute & solvent
3. crush solute into very fine powder

3) When a solute is added to water, what happens to the freezing point? To the boiling point? Why?

fp will be ~~decr~~ depressed
bp will be elevated
Solute interfers w/ solvent's fp & bp

4) Calculate the molarity of a solution if 236g of HI is dissolved in 17,500mL of solution?

$\frac{236\text{ HI}}{128\text{ g/mol}} = 2\text{ mol}$ $\quad M = \frac{2\text{ mol}}{17.5\text{ L}}$ $\quad \frac{17,500}{1000} = 17.5\text{ L}$

$M = 0.11\text{ M}$

5) Determine the mass of solute in 2000mL of a 0.25M solution of $CuSO_4$.

1
64
32
64
160

$0.25 = \frac{\left(\frac{x}{160\text{g}}\right)}{2\text{ L}}$ $\quad 80\text{g } CuSO_4$

6) Calculate the molarity of 114g $Al_2(SO_4)_3$ in 1500mL of solution.

$\frac{1500}{1000} = 1.5\text{ L}$ $\quad 342\text{g}$

54
96
192

$M = \frac{\left(\frac{114\text{g}}{342\text{g}}\right)}{1.5\text{ L}}$ $\quad 0.22\text{ M } Al_2(SO_4)_3$

7) Calculate the weight of KBr needed to make 200g of a 5% solution.

$5\% = \frac{x}{200\text{g}} \times 100\%$ $\quad 10\text{g } KBr$

8) Calculate the mass of solute that is needed to make 350mL of a 0.1M solution of C_2H_5OH.

$0.1\text{ M} = \frac{\left(\frac{x\text{g}}{46\text{g}}\right)}{.35\text{ L}}$ $\quad 1.61\text{g EtOH}$

9) How many milliliters of a solution of 4.00 M KI are needed to prepare 250.0 mL of 0.760 M KI?

48mL
47.5mL

$4.00(x) = (25)(.760)$

$0.048L \times 1000 =$

10) How could you prepare 250 mL of 0.20 M NaCl using only a solution of 1.0 M NaCl and water?

50mL

$(25)(.20) = 1M(x)$ .05L

Acids and Bases (Vocabulary: acid, base, conjugate acid, conjugate base, proton donor, proton acceptor, pH, acid-base theories, strong acid, weak acid, strong base, weak base, neutralization reaction, titration, acid/base nomenclature)

1) Complete the table:

Properties of Acids and Bases	
Acids	**Bases**
① Taste Sour ② React w/ metals ③ produce H^+ ions in water ④ Change A-B indicator such as litmus	① taste bitter ② React w/ animal tissue ③ produce OH^- in H_2O ④ Change A-B indicator such as

2) What is the difference between a strong and a weak acid?

Produce more H^+

strong acids have a higher degree of ~~diseosi~~ dis in H_2O than.

3) What is the difference between a strong and a weak base?

Produce more $[OH^-]$

4) Complete the table:

Solution	Identify as weak or strong acid or base	Name
$HC_2H_3O_2$	weak Acid	Acetic acid
$HClO_4$	strong acid	perchloric
HCOOH	weak acid	Formic acid
HBr	strong acid	hydrobromic
HCl	strong acid	hydrochloric
HF	weak acid	hydrofluoric
HI	Strong Acid	~~Eo~~ hydroiodic
HNO_3	Strong Acid	nitric acid
H_2SO_4	strong Acid	Sulfuric acid
KOH	Strong base	potassium hydroxide
NaOH	strong base	Sodium hydroxide (Lye)
NH_3	weak Acid	Ammonia

5) Complete the table and answer the questions.

Average pH of Common Substances

Item	Average pH	Acid,Base, or Neutral
Baking soda	8	B
Coca-Cola	2	A
Coffee	5	A
Dish detergent (hand washing)	6	A
Dishwasher detergent	12	B
Lemon juice	2	A
Tide laundry detergent	11.5	B
Vinegar	3	A
Water, pure at 25°C	7	N
Water, municipal	7.5	B
Water, rain	5.5	A

✓ What substance is the *most acidic*?

Lemon juice
coke

✓ What substance is the most basic?

Dishwasher detergent

6) What is the pH of a solution with a hydrogen ion concentration of 0.045 M?

$-\log[.045] = 1.35$

7) What is the pH of a 2.54×10^{-3} M HCl solution?

$-\log[2.54 \times 10^{-3}] = 2.59$ (2.60)??

8) The pH of an unknown solution is 6.35. What is the hydrogen ion concentration of the solution?

$[H^+] \neq 10^{-6.35}$ $[H^+] = 10^{-6.35}$ 4.47×10^{-7} M

9) The pH of an unknown solution is 12.83. What is the hydrogen ion concentration of the solution?

$[H^+] = 10^{-12.83} = 1.48 \times 10^{-13}$ M

10) Identify the conjugate base for the following:

a) HCl Cl^-

b) H_2SO_4 HSO_4^{-1} / SO_4^{-2}

c) H_2O OH^-

11) Identify the conjugate acid for the following:

a) NO_3^- HNO_3

b) NH_3 NH_4^+

c) $H_2PO_4^-$ H_3PO_4

d) H_2O H_3O^+

12) Label the acid, base, conjugate acid and conjugate base for the following:

a) $HCN(aq) + H_2O \rightarrow H_3O^+(aq) + CN^-(aq)$

acid base con acid con base

b) $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

base acid con acid con base

13) During a titration process, 35mL of 2.0M H_2SO_4 neutralizes exactly 20.0mL of NaOH.

a) Predict the products
b) Balance the equation
c) Label the acid, base and salt
d) Name the salt
e) Calculate molarity of the base solution.

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$

base acid salt water

Sodium Sulfate

$(35mL)(2.0M) = (20.0mL)(X)$

3.5 M NaOH